

Public Health Confronts the Mosquito:

Developing Sustainable State and Local Mosquito Control Programs



Interim Recommendations
of the National Mosquito Control Collaborative



ASSOCIATION OF STATE AND
TERRITORIAL HEALTH OFFICIALS

PUBLIC HEALTH CONFRONTS THE MOSQUITO:

DEVELOPING SUSTAINABLE STATE AND LOCAL MOSQUITO CONTROL PROGRAMS

INTERIM RECOMMENDATIONS OF THE MOSQUITO CONTROL COLLABORATIVE

A PROJECT OF THE
ASSOCIATION OF STATE AND TERRITORIAL HEALTH OFFICIALS

In partnership with
The National Association of County and City Health Officials

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If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org.
You can submit comments electronically, by fax or by mail.

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Association of State and Territorial Health Officials (ASTHO)

ASTHO is the national non-profit organization representing state and territorial public health agencies of the United States, the U.S. Territories, and the District of Columbia. ASTHO's members, the chief health officials of these jurisdictions, are dedicated to formulating and influencing sound public health policy and to assuring excellence in state-based public health practice.

National Association of County and City Health Officials (NACCHO)

NACCHO is the national organization representing local public health agencies. NACCHO supports efforts that protect and improve the health of all people and all communities by promoting national policy, developing resources and programs, seeking health equity, and supporting effective local public health practice and systems.

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EXECUTIVE SUMMARY AND MAJOR RECOMMENDATIONS

Mosquito control is an important and basic public health function. The rapid spread of West Nile virus across the U.S. in the last five years speaks to the continuing need for organized mosquito control activities. States and local communities are challenged to develop and maintain these essential vector control programs, especially in tight budgetary times and when emergency situations have quieted.

THE MOSQUITO CONTROL COLLABORATIVE

In response to needs voiced by the mosquito control community, the Centers for Disease Control and Prevention, National Center for Infectious Disease, Division of Vector-Borne Infectious Disease sponsored ASTHO to develop a set of recommendations for creating sustainable state and local mosquito control programs. Because mosquito control involves many players, ASTHO convened the Mosquito Control Collaborative (MCC or the Collaborative), a body comprised of state, local, and federal representatives from public health, environmental, and agricultural agencies, as well as other organizations intimately involved with vector control and public health. Because mosquito control efforts begin at the community level, ASTHO invited the National Association of County and City Health Officials (NACCHO) to join the project as a partner.

The following document consists of the interim recommendations developed by the MCC from February through June 2004. The purpose of this document is to serve as a catalyst for discussion. As state and local agencies learn more about effective mosquito control practices during the 2004 mosquito season, the interim recommendations, by necessity, will evolve. ASTHO is broadly soliciting feedback on the interim recommendations on behalf of the Collaborative from June through September 2004. After reviewing the comments, the Collaborative will develop final recommendations in winter 2005.

SUMMARY OF RECOMMENDATIONS

The Collaborative identified four major components of successful mosquito control efforts. Each section includes a series of planning and action checklists to aid states and localities in their planning activities.

PLAN AHEAD

Developing an effective mosquito control program takes time and preparation. Timely action, collaboration with other jurisdictions, and development of a plan to manage the challenges of mosquito control are over-arching requirements that impact all other recommendations and findings. Governments should not wait for a crisis to prepare. The Mosquito Control Collaborative has identified numerous strategies for effective planning and ordering of activities. Understanding the structures and roles of the state, local and federal participants, defining workforce and training requirements, identifying legal authorities and funding alternatives, and developing strategies for evaluating programs are elements that should be included in any successful planning effort.

The structure chosen to implement mosquito control activities is critical to their success. States, localities, and the federal government all have active roles in mosquito control. The exact roles of each will differ among the individual states and localities. Whatever structure is chosen, it should be based on solid legal authority to act. The structure of the funding mechanism for mosquito control activities also impacts the ultimate sustainability of the program or activities.

Each government unit must also assess the capacity of its workforce to accomplish its mosquito control goals, including identifying tasks it has the ability to accomplish in-house and those that may need to be obtained from the private sector. Regardless of how mosquito control is accomplished, governments must also consider the impact of the intended control strategy on the public's health and the environment. Finally, a thorough evaluation of mosquito control activities is imperative to establish credibility with those directly impacted by control activities, supporters and funders, and to learn from past mistakes.

INVOLVE OTHERS

The foundation to any successful mosquito control action is involving key participants early in the process. Governments should develop a strategy for

involving others, which includes identifying and engaging a wide variety of stakeholders. Because mosquito control issues can be contentious, successful programs look to identify all points of view early, present relevant scientific information in a transparent format, and work to a negotiated agreement, where necessary.

Governments should take care to identify the individuals, organizations, and agencies with a stake in mosquito control decisions. A variety of mechanisms should be used to target appropriate outreach to stakeholders. Special care should also be given to provide decision makers solid information upon which to base policy.

USE THE BEST SCIENCE AND DATA

It is critical that science drives the assessment of local and state needs, strategies selected, and design and monitoring of mosquito control programs. There are numerous proven methodologies and practices that guide the best mosquito control programs. All programs need to be based on an identified need that is matched with local and state resources and technically sound strategies.

A quality mosquito control program has at its foundation a solid understanding of the timing and distribution of human and animal disease cases of mosquito-borne diseases. Access to epidemiologic capacity to conduct surveillance of mosquito-borne diseases in the human population, and monitor disease and the distribution of relevant animal and insect populations, is critical to begin any mosquito control activity. States and localities must also determine their mosquito control needs. A scientific response to combat a nuisance mosquito may look very different from a program to combat mosquitoes carrying disease.

Control strategies can focus on preventing the emergence of adult mosquitoes (larviciding), addressing mature insects (adulticiding), and other prevention measures such as breeding pool reduction and bite prevention. The mix of strategies used by each state and local community will vary based on their individual political, legal, environmental, geographic, and funding concerns. The Collaborative outlines the following three program levels for mosquito control activities based on available resources:

- *Level I Minimal Program*– Describes the activities a community can take with no resources to support a mosquito control program.
- *Level II Intermediate Program*– Identifies activities communities with little to moderate resources can undertake even if they cannot mount a comprehensive program.
- *Level III Comprehensive Program*– Details the activities, by season, that a community with moderate to full resources can accomplish.

INFORM THE PUBLIC

Mosquito control programs need the support of an informed public. Many of the successful strategies for control involve individuals, their families and their neighborhoods. The public also has concerns about the problems related to mosquito populations and about insecticides and spraying. Development of a communications plan that includes public education about preventing the breeding of mosquitoes, personal protection guidance, and the activities and success of the agencies involved is critical to the success of the program.

INTRODUCTION AND BACKGROUND

THE MOSQUITO CONTROL COLLABORATIVE

In early 2004, the Association of State and Territorial Health Officials (ASTHO) assembled the Mosquito Control Collaborative (MCC or the Collaborative). The purpose of the Collaborative is to develop a set of recommendations to address state and local needs in establishing, maintaining, and funding mosquito control programs. The Collaborative is comprised of representatives of state, local, and federal public health, environmental, and agricultural agencies as well as other organizations intimately involved with mosquito control and public health. Because mosquito control efforts begin at the community level, ASTHO involved the National Association of County and City Health Officials (NACCHO) as a partner early in the project. Funding for this project was provided by the Centers for Disease Control and Prevention's (CDC) Division of Vector-Borne Infectious Disease.

Discussions at the 2003 West Nile Virus conference in New Orleans prompted the formation of the MCC. At that meeting, public health organizations and agencies discussed the problem of the deteriorating infrastructure for preventing mosquito-borne disease in the United States. Mosquito control is an important and basic public health function that must be recognized and supported. One solution identified was to develop recommendations to help states and localities in their mosquito control activities.

Further motivation for forming the MCC came from the Mosquito Abatement for Safety and Health (MASH) Act (Public Law 108-75). The Act authorizes grants to states for coordinating mosquito control programs and assisting local governments with assessment and planning activities. Grants are also authorized to localities for mosquito prevention and control activities. As of June 1, 2004, Congress had not appropriated any funds to cover the cost of the MASH Act. The MCC's recommendations will serve as a resource to states and localities should funds for MASH Act implementation ultimately become available.

While the 2004 mosquito season has already begun in many jurisdictions, it is important to realize that the work of the Collaborative will aid vector control efforts well beyond this year. The dialogue and

recommendations identified through the Collaborative provide guidance into the future for local and state jurisdictions as they address mosquito borne illnesses.

PUBLIC HEALTH CONFRONTS THE MOSQUITO: INTERIM RECOMMENDATIONS

The following document consists of the interim recommendations developed by the MCC from February through June 2004. The purpose of the document is to serve as a catalyst for discussion. As state and local agencies learn more about effective mosquito control practices during the 2004 mosquito control season, the interim recommendations, by necessity, will evolve. To this end, ASTHO is soliciting feedback on the interim recommendations from June 2004 through September 2004 from individuals and organizations interested in mosquito control. After reviewing the comments, the Collaborative will develop final recommendations in winter 2005.

Because mosquito control is a multi-faceted issue, by design some sections of the interim recommendations contain information that overlaps with other sections in the document. After each section there is a "Planning and Action Checklist" that highlights the major decision points and recommendations from that section. Finally, the interim recommendation document, while comprehensive, does not capture every available resource on the issue of mosquito control.

A list of resources is included at the end of the document. During summer 2004, ASTHO will continue to gather and post relevant resources on the web version of this document.

If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org. You can submit comments electronically, by fax or by mail.

HISTORY OF MOSQUITO CONTROL AND THE THREATS TO PUBLIC HEALTH

Mosquito-transmitted diseases have existed in the Americas since long before European settlement. Eastern (EEE), and Western (WEE) equine and St. Louis (SLE) encephalitis viruses are examples of such long-term threats (Scott TW & SC Weaver, *Adv. Virus Res.* 37:2377-328;1989). With the coming of the Europeans to the New World, additional diseases, such as malaria, dengue and yellow fever were added to the mix of vector-borne diseases. Most people today are unaware that malaria extended throughout the United States and into southern Canada in the 1800s (Ackerknecht EH. *Bull. Hist. Med. Suppl.* No.4:1-142;1945). Before the widespread use of motor vehicles, EEE and WEE viruses caused major epidemics in the horse population that resulted in substantial economic losses.

In recent years, with increasing intercontinental movement of goods, people and animals, a variety of new and exotic disease problems have been encountered. These emerging infectious diseases include Severe Acute Respiratory Syndrome (SARS), Ebola virus (Reston strain) and West Nile virus (WNV). These diseases are zoonoses, or diseases of animals that can be transmitted to humans. Many zoonoses, such as WNV, are transmitted by vectors, such as mosquitoes or ticks. WNV has spread from coast to coast in only five years. Given the increasing globalization of travel and commerce, it is likely that other exotic agents will be transported and established in the United States or in other areas of the Americas.

The first organized mosquito control programs were established in the early 1900s. One of the earliest programs began controlling nuisance mosquitoes around the San Francisco Bay area in 1903. By 1997, a national survey found 345 mosquito control districts or programs in the United States (*Directory of Mosquito Control Agencies in the United States*, American Mosquito Control Association, 1999). These programs served a population of over 97 million, at an estimated cost of \$231.7 million (slightly more than \$2.00 per person per year).

The cost of vector-borne disease prevention is normally less than the cost of control after an epidemic begins. Not only is emergency control more expensive, but there is also the added cost to treat disease cases that might otherwise have been

prevented. The average cost per patient hospitalized with WNV infection in Louisiana in 2002 was \$51,826 (A. Zohrabian, unpublished report, www.cdc.gov/ncidod/dybid/westnile/conf/February_2003.htm). The cost of WNV to the U.S. equine industry may be in the billions of dollars. These numbers fail to address the additional emotional cost to families of victims of mosquito-transmitted disease, changed quality of life of the victims and similar issues.

In addition to the impact on human and veterinary health, arboviruses frequently have a major impact on wildlife, including threatened and endangered species. In 2002 alone, it was estimated that more than 2 million birds, including endangered species, died from WNV infection (CDC, unpublished data). In 1984, 7 of 39 captive whooping cranes, an endangered species, died from EEE infection in Patuxent, Maryland (Dein FJ, et. al. *J. Am. Vet. Med. Assoc.* 189:1006-1010;1986).

PLAN AHEAD

Developing an effective mosquito control program takes time and preparation. Timely action, collaboration with other jurisdictions, and development of a plan to manage the challenges of mosquito control are over-arching requirements that impact all other recommendations and findings. Governments should not wait for a crisis to prepare.

The Mosquito Control Collaborative has identified numerous strategies for effective planning and ordering of activities. Understanding the structures and roles of the state, local and federal participants, defining workforce and training requirements, identifying legal authorities and funding alternatives, and developing strategies for evaluating programs all should be included in successful planning efforts.

STRUCTURES AND ROLES

The structure chosen to design, implement, and evaluate a mosquito control program is critical to the success of the program. Organizationally, a challenge will be to assure that the programs will protect the public's health; that policies developed to give direction to the programs are appropriate; and that there will be a proper assessment of actions taken.

The options available for structuring a mosquito control program are diverse. Control programs in the United States may include independent mosquito control districts; county/city/parish health departments; decentralized and non-specialized agencies, such as public works; or private companies, such as mosquito control contractors and pest control operators. The best choice for a particular entity depends on many variables that are ideally identified at the beginning of the selection process. Funding of mosquito control is usually dictated by local conditions and may relate to the program structure chosen. Some of the options are: dedicated mill levy, usually through a voter-approved special taxing district; fixed charges added to each household water meter account; local sales tax; or the general revenue fund.

Local, state, and federal agencies all have important roles and inter-relationships. Because mosquito

control is often primarily a local responsibility, citizens will look to local government as their first contact. State and federal governments are also recognized as playing an important role by providing additional resources and technical assistance to local leaders. The state has a responsibility for overall planning, guidance, and leadership, especially during public health emergency situations. However, the role of the state in mosquito control varies from state to state, with some states providing direct mosquito control services for local communities. While acknowledging the many variations among states and localities, traditional divisions of responsibility can be generalized.

Federal Roles

The federal government oversees issues of national concern. Congress, the Executive Branch, the federal legal system, and federal agencies create indicators and standards, and disburse funds to the states and local governments to be used to respond to the problem. Federal agencies such as the Centers for Disease Control and Prevention (CDC) are available to provide technical assistance to state and local governments. Additionally, the resources of federal agencies, including CDC and the Federal Emergency Management Agency (FEMA) may be available in the event of a disaster declaration. The requirements for accessing emergency resources are stringent, and thorough record keeping is mandatory. Also, the U.S. Department of Agriculture (USDA) is concerned with mosquitoes because they are livestock pests and transmit livestock diseases. Some of these diseases, like certain encephalitis viruses and West Nile virus, are zoonoses that also affect humans.

Specific federal roles as they relate to mosquito control include:

- Allocation of available resources to state and local governments
- Creation of standards and indicators
- Scientific analysis of trends in the mosquito population
- Weather forecasting
- Development of public information strategies and campaigns
- Maintenance of web sites on mosquito control and mosquito-borne illnesses
- Technical assistance to state and local jurisdictions

CDC has forged partnerships with other federal agencies and national organizations concerned with mosquito control and mosquito borne-illness. Annual conferences on emerging infectious diseases and West Nile virus have provided opportunities for dissemination of scientific information and training of state and local officials and other interested parties.

Furthermore, community awareness of mosquito control issues has been enhanced by the development of national public information campaign materials and the maintenance of web sites and list serves to provide timely, credible information to state and local governments and the public.

State Roles

The implementation of mosquito control strategies differs considerably among states. States often assume mosquito and mosquito-borne disease control responsibilities during and after emergencies when local resources are compromised or overwhelmed. Additionally, because of organizational or geographic considerations, some states also provide direct mosquito control services to communities.

Generally, the state oversees issues of state-wide concern and provides support services to local governments. The states are a strategic resource (political, technical, and legal) to local governments just as the federal government is a strategic resource to the states. Interstate and international relationships and agreements may be needed to deal with border areas. State agencies work with the media to assure that consistent messages are communicated statewide to physicians, veterinarians, and the public, and provide educational materials to the clinical

community and the general public. State public health laboratories also play an important role in mosquito-borne disease control efforts.

Mosquito control policy continues to evolve as new issues emerge. A compilation of state-specific mosquito control statutes by the National Conference of State Legislatures illustrates the many different approaches to mosquito control policy and implementation of programs. Many states delegate responsibilities for mosquito control and mosquito-borne illness to one or more state agencies while others have established mosquito control districts.

Often the lead state agency is charged with developing a statewide planning process to address new and emerging mosquito control issues. Some states have already developed statewide plans for mosquito control. Representation from key stakeholders is important to the success of a planning process.

State roles include:

- Development, collection, and analysis of state-specific data on mosquito-borne illness
- Development of state level policy recommendations
- Implementation of laws and regulations regarding mosquito control, disease surveillance, and reporting
- Coordination with federal agencies and neighboring states
- Development of state plans to address mosquito control
- Allocation of available resources to assist with local programs for mosquito control
- Maintenance of state information hotlines and web sites
- Development of statewide public information campaigns
- Technical assistance to local jurisdictions
- Evaluation of statewide efforts to combat mosquito-borne illness
- Public health laboratory services

Local Roles

Local governments implement mosquito control programs by creating tactical responses to emergency or ongoing threats to urban and rural citizenry. Support for this effort (financially, scientifically, legally, legislatively) may or may not come from the state. In order to garner public support for an

integrated mosquito control program, all levels of government are expected to work together. Some of the challenges in mosquito control can come from disagreements on how to handle federal land, state land, and local parks and natural areas. Strategies to shape action should be developed well in advance of a response action being taken. It should not be expected that any single agency can effectively respond alone to an environmental public health emergency of the magnitude of mosquito-borne illness.

Local level roles include:

- Designation of lead agency and authority within jurisdiction
- Development of mosquito control program within available resources
- Coordination among local agencies including public health, medical and veterinary communities
- Coordination with neighboring jurisdictions
- Surveillance, monitoring and reporting of virus activity and mosquito-borne illness
- Coordination with state lead agency
- Education of local officials
- Development of public information campaigns to educate public (especially high-risk groups)
- Evaluation of mosquito control efforts

Special Districts

Special mosquito control districts that carry governmental authority will also have license to make decisions that impact constituents living within district boundaries. Boundaries between districts and local governments may overlap. Intergovernmental agreements can be used frequently to assign responsibility, accountability, and to add clarity to programs that occur within multiple jurisdictions. To maximize economies of scale, multiple local communities can participate in cooperative agreements.

Mosquito control districts can be the option of choice to handle mosquito-borne public health threats over multiple seasons. Many states have enabling statutes that allow districts to be established by voter approval. These districts establish an infrastructure for monitoring and control actions, as well as provide a mechanism for funding. They can be one town, multi-county, or even state-wide. Mosquito control districts institutionalize mosquito control locally.

Mosquito control activities, by their very nature, have an effect on the environment. The ecosystem consists of a web of inter-relationships among organisms. Every practical effort must be made to reduce the negative consequences of mosquito control on the environment.

One way to do this is to use scientifically collected information to narrow the target of mosquito control. Not all mosquitoes are harmful and some are considered beneficial. Targeting is done by identifying and controlling only the mosquitoes that are nuisance and disease vectors. But even if control actions could be limited to a single species in a specific location, it should be realized that one cannot totally eliminate the environmental impact on other species in the system. There are, however, control options that have differing degrees of impacts on the environment. The goal is to choose the effective control tactic for the situation that has the least negative environmental impact.

It is prudent to use the less targeted controls, such as adulticide spraying, only when more targeted controls, such as source reduction and larviciding have failed to adequately reduce populations. Narrow spectrum larvicides (e.g., biological toxins, insect growth regulators) are to be preferred over broad spectrum larvicides. The overarching caution is to keep negative impacts on non-target species to the absolute minimum.

Whether the effect of an action is negative or positive is often a matter of values and opinion, and also often difficult to evaluate. For example, eliminating infected mosquitoes could help a bird population by preventing disease, but also could eliminate a food source upon which other animals feed. Nevertheless, it is important to evaluate environmental impacts of a mosquito control program.

To the level possible and practical, mosquito control programs should include an environmental review to assess the potential environmental impacts of the various control methods planned. Only with good information about both the benefits and consequences can policy makers and the public make appropriate choices about the kind of mosquito control program they want to have in their community. A decision matrix can help everyone understand the issues and decision points. [See Appendix A]

PLAN AHEAD—PLANNING AND ACTION CHECKLIST

- Determine if the state has legal authority for mosquito control planning and action at the state level. Are current statutes and lawful authority adequate to support decisions that must be made? Which agency will have the authority at the state level? If not identified in statute, the Governor may designate a lead agency for mosquito control, or legislation may need to be enacted to designate the lead agency and their responsibilities.
- Determine if the locality has necessary legal authorities to conduct mosquito control activities. Which agency will have the authority at the local level?
- Consider how best to structure mosquito control activities and programs. Are special districts a good answer for the community?
- Identify a collaborative format for elected officials and their appointees to address the problem.
- Determine a method among governments to assign mosquito control responsibility based on the level of expertise and capacity of the agencies involved.
- Clearly identify and understand the roles and responsibilities of the lead state and local agencies.
- Determine how will funding be structured and where will the money come from.
- Identify how existing environmental public health programs will be maintained if resources are overwhelmed by the emerging threat, such as West Nile virus. Identify a plan to keep other important programs functioning and at what level.
- Evaluate agency capability to fit into a response system that can “grow” as the event becomes larger and “shrink” as it decreases. Determine how to create such a system and how it will be activated.
- Determine how federal, state and local parks and natural areas be will handled. Establish or activate agreements to facilitate negotiations and action.
- Assign a designated spokesperson with responsibility to interact among governmental agencies and with the public and media.

THE ENVIRONMENT

Local and state health agencies may have entomologists and environmental specialists who can help mosquito control programs evaluate environmental impacts. Some agencies also have environmental epidemiologists, toxicologists, and other professionals who evaluate health risks. Close dialogue between these agencies and mosquito control programs during planning will pay off many times over when the program is implemented and people react to control activities in their community. If a local government has a mosquito control consultant, she or he may be able to advise the agency about how to find resources for an environmental review.

Another area of potential concern is mosquito control in wetlands. Special care must be given to wetlands and sensitive natural areas. Wetlands, streams, and even man-made drainage systems can provide habitat for a vast array of wildlife, including amphibians, mammals, birds, and insects. Wetlands also help

control flooding, improve water quality, and provide recreational opportunities. Draining healthy wetlands is a controversial and usually inappropriate response, while controlling breeding sites like sewer catch basins, puddles, containers, and poorly managed wet areas has broad support.

High levels of mosquito production frequently occur in wetlands that are used to treat domestic sewage (often referred to as man-made or constructed wetlands). While aquatic plants added to oxidation ponds improve wastewater treatment, they also lead to increased mosquito populations. Different physical designs and operating strategies of aquatic plant-based wastewater treatment systems can increase or decrease mosquito problems. Therefore, engineering considerations are important in the design of aquatic plant systems used for the treatment of wastewater. Careful design before construction and monitoring after construction can keep mosquito breeding within acceptable levels. Early input by mosquito-control

professionals can keep man-made or constructed wetlands from becoming a public health risk.

Keeping the public and environmental interest groups informed about relative risks is also critical. It is important to include the public and environmental interest groups in formative meetings leading up to implementation of a mosquito control program.

Another important consideration is that there is a major difference in what can and should be done for routine, integrated mosquito control actions, and what is done during a major public health emergency.

The concepts of relative risk and human values are obviously different in these different circumstances.

In the final estimation, fundamental to our democratic society is the ability of individuals and communities to have input in and ultimately determine the actions of their government. Americans place a high value on a healthy environment. How virus-infected mosquitoes are controlled in a community is a public decision to be based on many factors of science, emotion, the level and quality of information, economics, legalities, technology, politics, and importantly, human values.

ENVIRONMENT-PLANNING AND ACTION CHECKLIST

- Identify the environmental interest groups in the community.
- Involve the appropriate professionals and environmental interest groups early on in the process.
- Determine the community's levels of confidence in: a) its local government, and b) the available scientific information regarding risks to the public and the environment.
- Perform an environmental review of potential impacts prior to program implementation.
- Identify the scientific resources available to the community's program to evaluate risks and benefits of mosquito control actions.
- Set up a program to collect and identify mosquitoes by species and numbers to enable targeted control efforts.
- Analyze how to control mosquitoes in a way that protects the environment while still reducing the risk of disease-carrying and nuisance mosquitoes for the public.
- Make the results of the environmental review available to a broad public audience.
- Chose a knowledgeable and articulate spokesperson to carry environmental risk information to politicians and the public.

LEGAL CONSIDERATIONS

Communities and states must have a solid legal foundation for their mosquito control activities. An analysis of existing state and local laws, regulations, inter-jurisdictional agreements, and other legal mechanisms should be an activity of every control program. Many states and local governments are already well prepared with the necessary legal infrastructure. Examples of laws from these state and local governments, and template laws, provide an excellent start for those less prepared. Moreover, West Nile virus concerns may provide another opportunity to revise and update those authorities.

In many states, specific statutory provisions and protections outline the legal parameters for a

mosquito control program. Some states provide general statutory guidance through general health statutes and rules and general liability limitations. Depending on the existing laws in a given state, the public health threat level, and the existing political circumstances, it may be prudent to develop and introduce specific legislation dealing with the legalities of mosquito control. Government agency managers need to work closely with elected officials and the public to respond to any outbreak of mosquito-borne disease. These discussions should occur in advance of an outbreak.

There are hundreds of mosquito control programs throughout the country, each one with a different set of enabling authorities under which it operates.

However, there are commonalities that exist in the authorities that are required to manage a successful program. These are: (1) legal authority to exist and operate as a public entity; (2) general or specific definition of function; (3) enforcement authority; and (4) funding authority (discussed in the following section “Funding Alternatives”).

Establish Clear Legal Authority

The legal authority for a local mosquito control effort can be derived from state, county, and municipal laws. It can be general, such as general health or safety powers, or it can be specific, such as a mosquito control district. Below are examples of legal authority options that may give governmental leaders ideas for initiating or upgrading authority for their programs. The options are listed as a spectrum from basic to complex.

- **General Public Welfare and Safety.** Counties and municipalities have under their articles of incorporation a duty to maintain public safety. These are broad powers that can be used to authorize mosquito abatement. Lack of specificity usually means that a mosquito control program so authorized may have to continually justify its existence, procedures, and funding.
- **Local Public Health Authority.** This usually is characterized by a local board of health and a local health agency. Their enabling authority often has more specific language to protect the public from epidemics and nuisances. Environmental health programs historically include vector control to prevent encephalitis, even if mosquito control activities are not currently funded. Recent outbreaks of West Nile virus have caused many local public health agencies to build control programs on these authorities.
- **Statutory Enabling Authority.** State legislatures can provide enabling legislation to allow a county or municipality to operate a mosquito control program. Usually, there are funding opportunities provided by the statute.
- **Statutory Enabling Authority to Establish Mosquito Control Districts.** This option is a preferred way of institutionalizing a mosquito

control effort because it is specific, sustaining, and provides a proven funding mechanism.

- **Statutory Statewide Mosquito Control Program with Options for Participation by County and Municipal Governments.** This type of program is found where there is a major problem with pest mosquitoes. Complex regulations are promulgated by a commission, which prescribes parameters for control activities for counties and municipalities. Local governments can form districts and programs at their option.

Define the Lead Agency and Its Functions

Issues related to legal authority for mosquito control actions include defining in law who is responsible for those actions and efforts. An important question is, “What agency should have (or gain) authority for a mosquito control program in a given area?” Usually, control activities are the job of local government. Authority at the state level can empower local agencies and authorize their control activities. If there is an existing agency that is already involved, such as local public health or public works agency, its role could be expanded more economically than starting a new agency. State agencies may operate services in rural areas where local communities lack resources or initiative to develop a program.

The more sophisticated local government response is to establish a mosquito control commission and district. The district and its governing body become the focus of legal, as well as technical, public, media, and funding issues. Establishing a mosquito control district creates a funding mechanism for abatement actions through the ability to assess a tax. A district also defines responsibility. Where pest mosquitoes are an obvious community problem generally, mosquito control districts or even state mosquito control agencies are created.

In the absence of a district, local municipalities and county governments are responsible by default. In the case of recent West Nile virus activity, many political leaders were in that position for the first time with little expertise, funding, and legally prescribed guidance. A city or county with no mosquito control district may have a local health agency. Many cities and counties have funded and authorized local health agencies to control mosquitoes. Others have

contracted the work to private mosquito control companies. The benefits of privatization include quick response in an emergency, workforce benefits due to the seasonal nature of the work, and, importantly, shifting liability to the private sector.

Enforcement Authority

All states and counties have provisions in law dealing with public nuisances. Most have provisions to declare a property a public health nuisance or hazard and require mitigation by the owner. In the case of significant mosquito breeding harborage, such as tire piles, control authority is best when it is specific. Authority should include the ability to order mitigation, to levy fines if the owner is non-compliant, and to allow access for surveillance and control activities.

Environmental Permits and Regulations

Permits are required to apply pesticides, including for mosquito control purposes. The Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA) requires detailed record keeping of pesticide uses and conditions. The U.S. Environmental Protection Agency and state departments of environment or agriculture have jurisdiction over pesticide use and require applicators to be trained and licensed. Additionally, state and federal water and wetland protection laws may require additional permits. Emergency public health orders and declarations may reduce the need to obtain some of the permits and approvals. Each state is different in the permits they require and the exemptions for emergencies that are provided. Ongoing control programs are usually not exempted from permitting requirements. Most state wildlife agencies have provisions for the sampling and killing of wildlife for public health surveillance.

Anticipate and Define Liabilities

There are significant legal issues associated with the application of pesticides. In addition to governmental agencies charged with environmental protection, there are individuals and organizations that may strongly oppose pesticide use. Legal action and lawsuits can come from these groups, as well as from disease victims and their families who believe that government did not act fast enough or do enough mosquito control.

Liabilities include impacts on the environment, such as effects on beneficial insects and animals, water

supplies, plants, and also inanimate objects such as car finishes. Ways to limit liabilities include assuring proper and specific legal authority, following legal and labeling guidance, using state-of-the-art integrated pest management techniques, carefully managing practices and employees, promulgating liability limiting legislation, and contracting control actions to reputable companies. When contracting for services, it is important to clearly define liabilities and indemnification in the contract. Personal liabilities are involved not only with pesticide exposure to the public, but also with exposure of the applicators themselves.

Consequence Management

The development and operation of a mosquito control program requires careful consideration of all the consequences—including the negative ones—of its component activities. Some involve immediate reactions with legal liabilities; others may be subtle, long-term effects. In general, operation of a mosquito control program will require regular consultation with the appropriate legal counsel and risk management officer for the agency. Many of these consequences can be managed through relevant inclusions in state and local laws and through precautionary procedures. Listed below are potential consequences to be aware of when initiating or managing a mosquito control effort. Clearly, this list is not inclusive, as there are myriad circumstances and environments, and every community is different.

- Pesticide use. Pesticide use involves permitting and legal responsibilities. There are very specific parameters prescribing their safe and legal usage. Compliance with state and federal clean water laws and acquiring the appropriate permits are critical. Certain people and groups have special issues related to pesticide use, such as chemically hypersensitive individuals, aquaculturalists, organic farmers, and bee keepers. Consequences of pesticide use include adverse regulatory action, personal lawsuits alleging injury, damage to the environment (both acute toxicity and longer term effects), damage to insects considered beneficial, and damage to inanimate objects such as automobile paint.
- Biological controls. There could be a possible negative reaction due to perceived adverse and unknown effects of biological agents on the

environment. Mosquito-larvae-eating fish (*Gambusia*) and other biological controls may be considered exotic species and regulated or prohibited by a state wildlife agency. The lead mosquito control agency should regularly consult with the state wildlife agency if using biological controls.

- Property rights. A mosquito harborage may exist on private or preserved land. Even with clear legal authorities, these situations may require negotiations at high levels for resolution. Right-of-entry lawsuits may be minimized by including access provisions for mosquito purposes in public health laws.
- Funding and ballot initiatives. The political consequences of raising any kind of taxes for mosquito control could be significant. Governments must consider how the public will react and what other social programs will be impacted.
- Liability for contractor negligence. Contractors can make high-impact mistakes that bring with them the potential for liability to the government agency. Contracts should be written that protect public agencies from lawsuits. [See Appendix B: Bid and Contract Specifications]
- Employees at risk. The physical safety of employees working with potentially dangerous pesticides and other hazards is an important

concern. Federal and state laws require adequate supervision and thorough training in pesticide handling for employees.

- Personal privacy. Medical and personal information is necessary for epidemiological investigation. This information is confidential and sensitive, and should be treated as such, with procedures developed for its protection.
- Public education and risk communication. Public education about risks and precautions can be seen by some as a threat to tourism economies. Meeting with tourism groups, business leaders, and local politicians assures that they understand the importance of public education to reduce illness and unnecessary deaths. Also, spokespersons should be sensitive to business interests as they craft the message they send to the public.
- Personal responsibility. People may reduce their efforts to protect themselves from mosquitoes if they believe that government is controlling the disease. Information campaigns must stress the continued importance of personal protection activities to prevent mosquito bites, as part of the overall community mosquito control activities.

LEGAL CONSIDERATIONS — PLANNING AND ACTION CHECKLIST

- Review existing legal authorities and determine if they are specific enough to enable an adequate mosquito control program. Are current emergency powers authorities sufficient to use in an outbreak? Are specific state statutes and/or local ordinances needed to establish ongoing mosquito control activities?
- Determine if current laws, ordinances, and regulations provide sufficient enforcement authority to perform mosquito control activities.
- Regularly consult with legal counsel for issues of potential liabilities. Do the general public health and safety provisions adequately prevent liabilities?
- Inventory the pesticides and other control methods used in mosquito control activities. Determine the applicable regulations and permits covering the control activities.
- Contact all regulatory and land use authorities prior to any control activities.
- Carefully review all elements of the mosquito control activities to determine the possible consequences of each element. Develop a strategy to minimize and address these consequences.

- No action. There are significant consequences to doing nothing or having an inadequate response to West Nile or other mosquito-borne disease threats. Individuals who became ill and their families have sued agencies for lack of adequate response. Program directors and elected officials have been held responsible in the past by the public for failing to take action. Governments must be prepared to manage the consequences if they choose not to have an active mosquito control response.

FUNDING ALTERNATIVES

Financial options follow the organizational and legal decisions. Communities and states have choices regarding how to fund mosquito control programs. Alternatives can range from dedicated mill levies and surcharges on utility bills to general tax revenue and special assessments of properties. Each community must decide the level of funding that they are willing to devote to mosquito control and the best ways to raise or commit those resources.

One of the most difficult tasks in initiating and maintaining a mosquito control program is identifying and acquiring sustainable funding for the program. Mosquito control programs usually have more than one funding source. The benefits of diversified funding are obvious and include flexibility, stability, and the ability to add cumulative resources in times of an epidemic. Options for funding mosquito control activities include:

- County and Municipal General Fund. These funds can be one-time or sustaining. They usually go to a local office or agency (such as a local health department), but can go directly to a contractor for mosquito control services. A mosquito control program can seek support from multiple counties and municipalities to reach an economy of scale adequate to support a reasonable program.
- Mill Levy. This is a property tax, generally collected through a special tax district (mosquito control district or other district), that usually requires voter approval. Mosquito control districts may have borders independent of existing political boundaries. Resources collected by local governments are published and can be monitored by control program support groups.
- Benefit Assessments. Some states and regions use benefit assessments for property owners based on particular benefits to that property. These may be levied by a mosquito control district or other entity.
- Utility Bill Surcharge. Added to consumer billing, a utility bill surcharge has low administrative overhead to collect and can often be added without voter approval. This mechanism is useful when a city or county has its own utility program, such as electricity or trash pickup.
- State General Fund. Legislative funding can be one-time or sustaining. Sustaining funds are usually associated with a statutory statewide program.
- Federal Grants. As seen during the current West Nile virus epidemic, the CDC may provide emergency money to state and local governments in need, as pass through dollars from state agencies.
- State and Federal Emergency Funds. Federal, state, county, and municipal governments have emergency accounts for disaster relief. Control efforts for epidemics may qualify for this source of support.
- Private Grants. Where special land and wildlife resources are at risk or responsible for mosquito harborages, grants may be available to defray control activities. Private entities that maintain wetlands for parks or wildlife refuges have contributed to the cost of control efforts.
- Reimbursement by Government Agencies. Other government entities, especially federal agencies, can be sources of funds. Agencies whose operations or land holdings add to the magnitude of a mosquito control program, such as the Army Corp of Engineers or the National Park Service, have contracted with local control programs for services.

FUNDING ALTERNATIVES — PLANNING AND ACTION CHECKLIST

- Identify funding sources that are currently available for a mosquito control program. Survey agencies that have successful programs to find an appropriate funding model. Talk to people who have experience in acquiring funding for programs.
- Identify the right program for the jurisdiction before asking for funds.
- Develop strong and diverse support from the community for the program. Is there a local elected or appointed official who is identified as a leader in fiscal matters that can become a champion for the program?
- Seek funds from multiple sources.
- Seek sustained funding sources, at least as the base for a program.
- Use scientifically sound data to support funding efforts.
- In the case of emergencies, determine in advance if funds can be temporarily diverted from a lower priority program.
- Determine if there an existing special district (e.g., park district) that might be used to carry an additional program to control mosquitoes.

New funding may be available in the future from the Mosquito Abatement for Safety and Health Act of 2003 (MASH Act). The MASH Act authorizes grants through the Centers for Disease Control and Prevention to states for coordination of mosquito control programs within a state and assisting localities by providing assessment and planning grants. The MASH Act also authorizes operating grants directly to localities that have conducted assessments and have coordinated with the state to prevent mosquito-borne diseases. Funds have not yet been appropriated for the MASH Act.

WORKFORCE AND TRAINING ISSUES

It is important that a team responding to a mosquito-borne illness or any environmental public health emergency possess both technical and communication skills. Credibility is enhanced if the person communicating the crisis to citizens has an understanding of how to converse in terms the public can comprehend. Everyone has the capacity to learn enough from a scientifically rich discussion to make an informed decision. Underestimating the capability of a lay person to understand an issue can be a fatal mistake and cause a program to fail, no matter how good the intentions. The workforce must acquire

skills, knowledge, and abilities that go beyond the scientific or technical skills. There are several workforce and training issues that are important to a mosquito control program.

- Certification of applicators. Individuals who apply pesticides must be licensed, in the appropriate category (usually public health) by the responsible state agency (usually the department of agriculture).
- Entomologists. At least one individual must be available who has a thorough background in mosquito biology and identification and can identify all common species occurring locally.
- General training in mosquito biology and control. All technical staff must have sufficient understanding of the biology of mosquitoes so that they can perform the activities associated with surveillance and control. Such training is often available through government agencies, state or regional mosquito and vector control associations, university extension, or commercial sources, including home study courses.

WORKFORCE AND TRAINING — PLANNING AND ACTION CHECKLIST

- Identify the staffing and expertise needed for a comprehensive mosquito control and surveillance program. Differentiate between full-time and temporary worker responsibilities.
- Identify skill levels of each worker and compare those to the job responsibilities being assigned to that person. What qualifications will be needed to compose a well rounded team that will have the support of the citizens? Make sure properly credentialed people are filling roles appropriate for their skills, knowledge, and abilities.
- Determine who will make up the primary response team and how they be selected. Will staff be paid or voluntary or both?
- Determine whether adequate staff, equipment, and other resources exist within the governmental agencies responsible for the program. If they do not exist, investigate the use of private contractors.
- Confirm that the personnel system is equipped to handle the staffing and expertise needed for the program and for maintenance of other programs impacted by mosquito control demands.
- Determine how to incorporate temporary personnel if they will be used to implement a mosquito control program. How will they be paid? What skills and professional disciplines will be required of temporary personnel?
- Establish an organizational chart specific for the response action.
- Determine a communication protocol for the effective release of technical information and educate all staff about the protocol.
- Consider adding lay people from the community who can represent and advise on the interests of the citizens.
- Investigate liability issues when using volunteer and/or contract workers.
- Implement an accounting system to keep track of all of the resources used, including paid and volunteer staff.
- Create an evaluation process for private contractors and incorporate that evaluation into the contracts.

- Other specialists. Individuals who take blood samples from sentinel chicken flocks or wild birds must have appropriate training. Special permits or licenses are required for wild bird sampling. It is highly advisable for ongoing control programs to have an individual who can perform insecticide resistance testing. Other specialties might include a media and public relations specialist, GIS technician, and an ecologist or biologist.
- Zoonoses Epidemiologist. This individual will track human and animal cases through case reporting systems, as well as map the results of mosquito pool testing. The position is responsible for analysis of the data and making recommendations related to the level of control actions needed. Such positions are usually housed in state health agencies.

State agencies should assess their workforce needs and may be able to initiate training opportunities and

financial support for workforce development. State universities and local colleges can partner with health agencies to implement training programs. Professional associations can also provide pertinent training, often in partnership with state agencies.

To bridge gaps in capacity, communities may want to consider hiring consultants to provide temporary leadership, assist with hiring private contractors, and supply hard-to-find expertise as well as continuity.

EVALUATION OF MOSQUITO CONTROL PROGRAMS

The nature of the decisions made as part of mosquito control activities can be of great public significance. To determine the success of a mosquito control program, an agency should create an evaluation protocol. The program assessment should be objectively implemented with the ultimate goal of improving the program. Such a review must be done to establish credibility with those directly impacted by

control activities, supporters and funders, and to learn from past mistakes. Without a rigorous effort to identify how well the program performed, there may be unsubstantiated objections from many observers. There are examples available of evaluation tools that may be helpful in developing assessments for mosquito control programs.

At least three aspects of a mosquito control program should be evaluated individually in order to determine the effectiveness of mosquito abatement efforts: public response, technical issues, and legal issues. Once completed as stand-alone reviews, they should be combined in the aggregate to complete the picture. As part of the evaluation, an agency must consider both process and outcome measures to provide understandable measures of performance to the public.

Public Response

A government should determine the public's response to two different facets of its mosquito control activities—process and action. The public is broadly construed to include: residents, visitors, elected officials, interest groups, and the media. An agency should evaluate if the public felt included in the decision making process about the control program. A survey can be used to gauge public opinion: were they included in the decision making? Were they listened to and their ideas acted on in a positive way? If their individual or collective ideas were not a part of the final control plan, was a proper explanation given before the program was activated? Were the elected and appointed officials given sufficient information to make good policy decisions?

Additionally, mosquito control programs include community awareness strategies that encourage citizens to participate and not depend wholly on government or district personnel to solve the problem. A follow-up survey, polling or face-to-face meetings should take place to determine if the messages were heard and if they were acted upon satisfactorily. For example: did individuals voluntarily drain standing water from their property? Did they use insect repellent? Did they immunize their livestock? Did they empty water from bird baths, discarded tires, and other containers that can hold water and serve as a breeding ground for mosquitoes?

Technical Issues

An evaluation of all of the technical aspects of mosquito control is a significant undertaking and includes an appraisal of issues such as science, surveillance, epidemiology, medical interventions, and integrated pest management. A specific appraisal of each of these will involve establishing objective criteria that can be peer reviewed and withstand challenge from many fronts. The technical section may be the most questioned due to the complexity of how each individual component fits with the others to create a scientifically defensible action. Using the best available science to support a mosquito control program is central to minimizing public concern and protecting the environment from unwanted outcomes.

Many governmental agencies and special mosquito control districts may not have the capacity to design and implement a mosquito control program due to resource constraints. A private contractor may be the best choice to perform the work of mosquito control. Specially patterned review criteria will be necessary to determine how well the work was administered. Work performance standards should be created to provide an objective view of the success of the program. Performance standards should be included in all contracts. [See Appendix B: Bid and Contract Specifications].

There is a certain component of mosquito control that is non-negotiable and is required by regulatory agencies: the need to track all chemicals used to combat insects. Specific requirements administered by various agencies such as EPA or USDA mandate an inventory of products from cradle-to-grave—each chemical must be traceable from point of origin to point of application—to track where the material is at any given time.

A more detailed breakdown of the actual use of the chemical used is also important. Such as:

- Where was the chemical applied?
- How much was used?
- How was it applied?
- What were the spray volumes?
- Who did the application?
- Was GIS mapping used to define areas treated?
- What was the application rate, especially for adulticides?
- For adulticide applications, which areas or premises were not treated (no-spray sites)?

Legal Issues

As detailed earlier, grounding a jurisdiction's mosquito control activities in law is vitally important. Legal issues may be evaluated separately from the others due to their unique nature, but an assessment should be regularly undertaken in cooperation with legal counsel. What legal authority exists that can support mosquito control? Was the authority used properly? Did those with the authority reach beyond the margins established by the law without properly following legal protocol? Were those in charge unable, for whatever reason, to use the legal authority to its fullest in order to obtain a more successful program result? Was the intent of the law applied and was it adequate to meet intended consequences? What enforcement activities were aided by the law? What enforcements were hindered due to limitations in legal authority?

Develop Process and Outcome Measures

A successful evaluation progression will include both process and outcome measures. These include inputs, outputs, and quantitative outcomes of the mosquito control program. It is important to craft measures that are easy to understand, yet provide real information about progress on mosquito control efforts.

The process measures include how many or how much was expended in the effort. For example:

- How much money was spent?
- How many people did it take to operate the program?
- How much and what type of control agents were used?

- How many mosquitoes were collected and identified?
- How many light traps were used?
- How many miles were traveled or covered while adulticide spraying?
- How many complaints were registered?

This type of information is invaluable when designing and creating a budget for a program. It is important to keep track of these data to satisfy those who want to know the numbers and compare their community's program with other programs.

The outcomes are more difficult to measure.

Outcomes go beyond the counting of activities and inputs. There is increasing pressure for accountability and informing citizens of the actual benefit of programs. The public wants to know if they will be at decreased risk for disease if a program is implemented. They wish to know the impact on livestock infection from disease with the program being planned. Is adulticide spraying now necessary because the risk to human health from mosquito-borne illness is greater than that posed by the chemicals? These impact statements should be substantiated by science and conveyed to the public in a persuasive manner by credible people. Some non-subjective, easily measured outcome statistics are:

- Average percent reduction in numbers of mosquitoes (larvae or adults) based on pre- and post-treatment sampling (dipping or light traps, respectively)
- Reduction in numbers of mosquito complaint calls compared to previous years, to the long-term average, or to neighboring areas without mosquito control
- Changes in infection rates for humans and livestock

EVALUATION — PLANNING AND ACTION CHECKLIST

General Evaluation Considerations

- Determine who will perform the mosquito control program evaluation.
- Identify what criteria will be used to objectively review pre- and post-program implementation activities.
- Decide how the evaluation outcomes will be used to improve future program success.
- Develop evaluation outcomes that are transparent and can be openly communicated to the citizens.
- Create an evaluation tool that is flexible enough to provide needed information from an evolving program.
- Determine what “outcomes” of the program will most accurately offer a critique of the program in terms the public can understand.

Public Response

- Contact recognized community leaders to include in evaluation activities. This may include a member of the media, stakeholder groups, and citizen representatives.
- Create a feedback mechanism to determine how the public feels about their role in the decision making process.
- Establish a follow-up mechanism such as a survey to determine the success of volunteer efforts.
- Determine the success of public education and outreach campaigns in getting the public to act on mosquito control recommendations.

Legal Issues

- Inventory all applicable statutes, laws, ordinances, rules and guidelines that give authority to perform a mosquito abatement program.
- Determine if the existing laws are sufficient to support the program.
- If existing laws are not adequate, investigate what changes are needed to perform the functions of the program.
- Establish whether laws were properly administered. Review any legal challenges brought or decided about the mosquito control activities.

Technical Issues

- Create a peer review process of scientific data and recommendations.
- Determine if the communication protocol for the effective release of technical information has been followed.
- Track resources used for the program.
- If private contractors are used, create an evaluation process for assessing their performance and incorporate measures into bids and contracts.

INVOLVE OTHERS

The foundation to any successful mosquito control action is involving key participants early in the process. Governments should develop a strategy for involving others, which includes identifying and engaging a wide variety of stakeholders. Special care should be given to informing decision makers to give them solid information upon which to base policy.

DEVELOP A PLAN FOR INVOLVING OTHERS

Communities and states may organize task forces or advisory committees that involve other agencies, neighboring jurisdictions, stakeholders, other interested parties, and the public. Mosquito control decisions, like all potentially controversial and important public decisions, are made in a political environment. Elected officials may be on the firing line as they deal with options for the community. Health officials can provide scientific, technical, and medical information to support decision makers.

Where there is disagreement over the proper course of action to address a public health situation, advocates for the action and those opposing will be present. The presence of strong leadership is critical to emerge from such a situation with a negotiated outcome that serves the majority of citizens. In a situation with diverse opinions, it is essential to present the relevant scientific and public health information in the clearest and most transparent manner possible. If there is agreement on defining the problem, attention shifts to how best to respond to the threat. If there is debate around the problem, focused discussion to resolve differences must precede any subsequent steps.

A proactive approach to responding to differences of opinion is valuable to the general public. Citizens living in an area that is proposed for aerial spraying for mosquitoes, for example, will have varying opinions as to how and when it should occur, or if it should occur at all. Having a well thought out approach instills confidence. The importance of providing unbiased information to the debate cannot be overstated. Such information will carry the dialogue forward and must use language that is understood by the general public.

Developing a sound plan for stakeholder participation and community awareness begins with a compilation of information. This includes:

- Historical approaches to mosquito control in the jurisdiction
- Review of legislation or regulation governing mosquito control
- Description of current efforts
- Collection of all available data on mosquito-borne illness and nuisance mosquitoes
- List of key constituency groups that have expressed interest in the issue or have strongly opposed controls
- Compilation of best practices from similar jurisdictions
- Identification of mechanisms for working with the media

The primary responsibility for developing a stakeholder participation plan will generally be delegated to staff of a local governmental agency. Unless a designated mosquito control district has been established, this work will typically be tasked to the local public health agency, environmental protection agency, or public works agency.

ACTIVELY INVOLVE STAKEHOLDERS

Inclusion of people and organizations representing a wide array of backgrounds and opinions is paramount in creating ongoing support for mosquito control programs and developing consensus on the best approach for mosquito control. Examples of key stakeholders to involve include:

- Business, civic and governmental organizations such as chambers of commerce, neighborhood associations, cooperative extension services, parks and recreation, zoos, service clubs (e.g., Rotary club, 4-H) and industry groups (e.g., pest control operators, outdoor recreation sites).
- Environmental advocacy groups, bee keepers, organic farmers, ranchers, fish farmers, and outdoor recreation enthusiasts.

- Medical/hospital providers, veterinarians, emergency personnel, schools, the media, and advocates for special populations (e.g., the elderly, immunocompromised).
- Other participating agencies bring strengths to the program and that these attributes should be capitalized upon by properly applying them to the larger effort.

Jurisdictions can look to other examples of public health programs in their community for models of stakeholder participation. Examples may include tobacco control, HIV prevention programs, child and adult immunization programs, injury prevention (e.g., seat belt, safety seat and impaired driving prevention) and environmental protection programs (e.g., lead poisoning prevention, air pollution etc.).

Methods for stakeholder participation may include surveys, focus groups, telephone polling, public meetings and hearings, and roundtable discussions. Creation of mailing lists and e-mail list serves will provide additional points of contact and discussion among community partners.

Involvement of the media in promoting understanding of the problem, enlisting editorial support, and disseminating information is important. Most print and electronic media have specialists assigned to health and environmental issues. Local media can assist by providing information to the public regarding upcoming meetings and opportunities for input.

INFORM POLICY AND DECISION MAKING

Officials at the city, county, and state level all need to engage in discussions regarding mosquito control. Members of boards of health have a vital role to play in advocating for protection from mosquito-borne illnesses. To accomplish this, elected and appointed officials need accurate, clear, and concise data to make informed decisions about mosquito control. Policy makers will generally prefer brief written materials that identify a single contact person. Information presented to policy makers should include: surveillance data and current epidemiological trends regarding mosquito-borne illnesses; scientific information regarding mosquito habitats and seasonal patterns; options for a basic mosquito control program; costs associated with mosquito control;

public awareness campaign plans; and legal and regulatory implications. Examples of successful models and options from places with demographic and geographic similarities may also be of help.

Successful programs typically identify one or more champions who understand the issues and are willing to serve as an advocate and spokesperson in their legislative body (e.g., state legislatures, town council, county commissioners, district, etc.). Champions are often individuals who have been directly impacted by the issue. They may have a family member or constituent who became ill or they may have credibility with the public on issues of public health. Colleagues usually look to them for advice on health issues.

Involve Others — Planning and Action Checklist

General Stakeholder Considerations

- Consider how elected officials and their appointees will work in a collaborative format to address the problem. How will agencies work with elected and appointed officials?
- Determine how collaborating government officials and agencies will enlist citizens in the decision-making process and create a fluid mechanism that will get things done in a timely manner.
- Determine how divergent views will be addressed and resolved.
- Determine how leaders of advocacy groups and those in opposition will be chosen. Who will sit at the negotiating table?
- Once agreement is reached between all parties, decide how the message will be communicated to citizens to maintain support when implementation of the plan begins.

State Actions

- The lead agency for mosquito control should develop a planning process. This may include meetings of stakeholders, surveys, regional focus groups or town meetings, and other mechanisms to gain input and support for the plan.
- The lead agency should identify other stakeholders to include in statewide planning efforts, which may include:
 - Elected and appointed officials including such state boards and committees as state boards of health
 - Other state agencies (public health, environmental protection, natural resources, agriculture, emergency management)
 - Conservation groups (land, water, air)
 - Statewide organizations representing local government (counties and municipalities)
 - Business and industry (agriculture, tourism, medical/hospital, veterinary, pest control)
 - Public health (public health association, environmental health association, local health departments)
 - Recreation groups (fishing, outdoor sports)
 - Statewide media
- Consider input from private and quasi-governmental agencies, such as special districts, as experts in a particular function of the program.
- The lead agency should develop partnerships with land grant universities and medical and veterinary schools that have expertise and research and outreach capabilities.
- The lead agency should complete a plan for mosquito control, disseminating the plan to all stakeholders at the state and local level.
- Develop mutual aid agreements or memorandums of understanding with all partner city and county agencies, states, and countries.
- Establish a response system that is universally accepted and can be understood by all participants in the project if an epidemic is occurring. Look to existing response systems such as the Incident Command System as an option to manage the event if an epidemic is occurring.
- The lead agency should evaluate the success of mosquito control strategies and identify plans for addressing emerging issues.

Local Actions

- Identify lead agency for mosquito control at local level.
- Review state plans and consult with lead state agency for mosquito control.
- Identify jurisdictional boundaries and forge partnerships with neighboring counties and municipalities.
- Develop and implement a plan for stakeholder participation and community awareness. Key elements include:
 - Identification of one or more champions for mosquito control who are willing to serve as advocates and spokespeople in their legislative bodies.
 - Develop briefing materials on such items as historical approaches to mosquito control; current surveillance data; lists of key constituency groups; a compilation of best practices from similar jurisdictions; financial, legal and regulatory options for local plans; and public awareness campaigns for local officials.
 - Develop methods for stakeholder participation that may include surveys, focus groups, telephone polling, public meetings, and roundtable discussions.
 - Create mailing and e-mail lists to provide additional points of contact and discussion among community stakeholders.
 - Identify a primary spokesperson to inform the community about implementation of a mosquito control plan and to address issues and concerns regarding spraying, and if necessary, the presence of mosquito-borne illness.
 - Work with the local media to develop public information strategies and assist with campaigns to prevent mosquito-borne illness and promote community understanding and acceptance of the mosquito control program.

USE THE BEST SCIENCE AND DATA

It is critical that science drives the assessment of state and local needs, strategies selected, and design and monitoring of mosquito control programs. More is being learned each year as scientists and other experts continue to study mosquito control and disease transmission. These historical lessons and current best practices must guide the development, implementation, and evaluation of quality mosquito control programs.

There are numerous proven methodologies and practices that guide the best mosquito control programs. All programs need to be based on an identified need that is matched with state and local resources and technically sound strategies. There may be gaps in knowledge in some areas such as outcome evaluations.

Focal or homeowner-based mosquito control strategies may be perceived as an alternative for the public in affected communities. There has been a rapid proliferation of backyard mosquito control equipment and technologies, as well as suggestions for new or unproven alternatives to currently recognized effective mosquito repellents. There is little data on the efficacy of these methods, machines, and materials either for area-wide or focal programs, especially for mosquito-borne disease control. If the public believes that these alternatives are best for them (for example, because of intensive advertising), they could rationalize not authorizing public support for community-wide mosquito control. Therefore, organized mosquito control programs could suffer. These methods also do not adequately address the need for surveillance, monitoring, source reduction, or larval control—all basic components of integrated mosquito management. In addition to not providing area-wide protection, focal strategies usually are more expensive than the annual per person cost of organized mosquito control.

THE SCIENCE OF MOSQUITO CONTROL

A quality mosquito control program has as its foundation a solid understanding of the biology of the mosquito species that occur locally. This includes such information as where the larvae are found, where the adults rest, what time of day the adults look for a

blood meal, and what control measures are most effective against each species. In addition, control of disease-transmitting mosquitoes requires information on the timing and distribution of human and animal cases.

Epidemiology

Public health mosquito control efforts are driven by information accumulated and analyzed using the science of epidemiology. Epidemiologists at CDC, state health agencies, and local health agencies work cooperatively to monitor mosquito-borne illnesses. Monitoring the timing and distribution of both human and animal cases of mosquito-borne illness provides the basis and the targets for mosquito control in the field.

As identified by CDC, the goals of surveillance for human cases are to:

1. assess the local, state and national public health impact of West Nile virus and other mosquito transmitted diseases and monitor national trends;
2. demonstrate the need for public health intervention programs;
3. allocate resources;
4. identify risk factors for infection and determine high-risk populations;
5. identify geographic areas in need of targeted interventions; and
6. identify geographic areas in which it may be appropriate to conduct analytic studies of important public health issues.

Human case surveillance involves receiving and recording reports of illness; confirming diagnoses; interviewing doctors and patients to determine the timing, geographic location, and conditions of infection; and scientifically analyzing the data accumulated.

Monitoring human cases alone is considered inadequate when dealing with mosquito-borne disease. Using epidemiological techniques to monitor equine and avian cases is very important in establishing early trends and allowing reasonable response times for control activities. Reporting networks for animal cases involve veterinarians,

laboratories, wildlife agencies, agriculture agencies and organizations, and also the general public. These reporting systems require proactive and ongoing effort to implement and maintain. State health agencies collaborate with these partners to establish, maintain, and analyze these databases. The state also helps define the parameters of reportable cases and keeps physicians informed of changes in case definitions, routes of transmission and treatment regimes. Developing guidelines and fact sheets on clinical features and treatment for physicians and personal protection guides for the public are ways the state health agency can provide important services to the medical community and the public.

Surveillance of Animal and Insect Populations Zoonoses are different from human-to-human diseases because they involve other animal hosts (and, frequently, insect or tick vectors). Much of the activity (transmission) of zoonotic pathogens takes place out of sight of, and physically removed from, humans. However, attacking the zoonotic cycle has the greatest impact in reducing the threat of disease in humans and domestic animals. By the time these diseases are detected in the human population it is often too late to have any impact on the transmission cycle. In fact, the zoonotic portion of the cycle may already be declining when human cases appear. At that point, the only effective strategies are avoidance, personal protection, and chemical control of the adult vectors (mosquitoes in this case).

To understand surveillance and monitoring strategies, it is necessary to know something about the ecology of the area, the mosquito species present, and the disease agents likely to be found. This information will set most of the parameters for the layout of the surveillance system. In general, adult mosquito collections (e.g., from light traps or gravid traps) are highest when traps are placed in an ecotone (the junction between two habitat types, such as forest and grassland, park land and urban housing, etc.). In monitoring for virus activity, roosting or nesting habitats of the bird hosts should also be considered in deciding where to place traps. Note that this is different from the placement of traps to detect the emergence of adult mosquitoes from larval habitats.

The objective of public health mosquito control is to prevent transmission of mosquito-borne diseases to humans, domestic animals, and livestock. Reduction

of nuisance mosquito species may be an added objective, particularly in areas where tourism and other outdoor activities are major contributors to the local economy. Nuisance mosquito management frequently focuses on different species (and different habitats) than public health mosquito control. However, a well organized integrated mosquito management (IMM) program can provide the basis for effective management of vector species.

Monitoring or surveillance as a part of a nuisance-based mosquito control program differs somewhat from virus surveillance programs. In the latter case, the objective is to detect activity of the vector species at the earliest possible point in time. Collections of larval mosquitoes in new or previously identified habitats often form the core of nuisance-focused surveillance. Adult mosquito surveillance is used mainly as an assessment tool to judge the effectiveness of control measures in nuisance based control programs. In disease prevention and control programs, adult mosquito surveillance plays a much larger role, since the risk of pathogen transmission is often linked to adult mosquito density, infection rates, and age structure of the female population.

PLANNING A MOSQUITO CONTROL STRATEGY

Communities need to define their desire and need for mosquito control before they create a program. A scientific response to combat a nuisance mosquito may look very different from a program to combat mosquitoes carrying disease. However, it is important to remember that there is not a clear distinction between “nuisance” and “vector” species of mosquitoes. For example, *Aedes vexans*, perhaps the most widely distributed nuisance species, also appears to be involved in transmission of West Nile virus, as well as transmission of eastern equine encephalitis virus in some areas.

It is important to recognize that mosquito and mosquito-borne disease control programs cannot be created at a moment’s notice, as too many agencies across the U.S. have learned in the wake of West Nile virus. As detailed in the “Plan Ahead” section, effective, efficient, and publicly embraced programs need to be planned and initiated well in advance of the onset of a disease outbreak or mosquito control emergency following a disaster. The best disaster or emergency responses come from ongoing programs

with trained personnel, adequate equipment, and good procedures already in place and operating.

Communities need assistance in assessing the existing and necessary scientific and technical infrastructure for a program. Citizens need to know what proactive and reactive options are available. Communities need models of successful programs to weigh against their resources. They need information about minimum criteria and standards for programs with limited resources. They also need models for threat assessment that are timely and site-specific.

Mosquito Control Strategy Basics

There are several ways to prevent the emergence of adult mosquitoes, which is generally the most economical strategy. Larvae are confined to the aquatic habitat, which can be clearly identified and treated. Methods include:

- Source reduction (remove, cover, drain, fill)
- Chemical control (larvicides)
- Biological control (mosquito fish, pathogenic fungi, etc.)
- Public education (role of the homeowner in reducing peridomestic larval habitats)—schools, service clubs, radio and TV, other focal points in the community

All larviciding operations should be monitored by dipping or other accepted technique to assess the efficacy of the application.

If larval control fails, is inadequate, or not feasible in a given setting, it may be necessary to control the adult mosquitoes that emerge from the larval habitats. Adult mosquito control must cover a larger area, since adults of many species can fly long distances (ten miles or more for some species), which can drastically increase the cost of protection. Adult mosquito control methods include:

- Personal protection (use of repellents, clothing, maintain door/window screens)
- Public education (educate, gain public support for the program, source reduction around the home)

- Adulticides (usually applied as ultra-low volume-ULV-sprays by truck- or aircraft-mounted equipment)

Because adulticiding can be a divisive issue in many communities, its use should be clearly justified by using a decision matrix that specifies what events will trigger a given level of response. A decision matrix specifies a range of activities or responses to a given set of predictive parameters. [See Appendix A: Decision Matrix]. For example, recent temperature and rainfall, mosquito density, levels of virus transmission in sentinels, etc., can be factored into decision-making. The decision matrix helps policy makers avoid indecision and provides justification and confidence for a particular course of action.

Use area maps to indicate treated and untreated areas, indicating reason for not treating an area (environmentally sensitive, opt-out, outside district boundary, etc.). Environmental parameters, such as temperature, wind speed and wind direction should be recorded during each application.

All adulticiding operations must be closely monitored, and the efficacy of the application should be assessed by pre- and post-treatment trapping, landing counts, or other techniques. All relevant application parameters (e.g., droplet size, flow rate, etc.) must be monitored in accordance with the product label.

Once communities have identified that mosquitoes are presenting a threat to the community, action must be taken based on the resources available to the state or community and the severity of the threat. Human disease and mosquito surveillance programs are necessary components for a public health mosquito-borne disease control program. Hit-or-miss programs will be ineffective.

MOSQUITO CONTROL STRATEGY—PLANNING AND ACTION CHECKLIST

- ❑ Determine the community's need surveillance for vector-borne disease.
- ❑ Determine what is involved in vector-borne disease surveillance. What agencies or groups will be involved in carrying out the surveillance program? How will coordination and communication be handled between the participating agencies?
- ❑ Identify the options for establishing a vector-borne disease surveillance and control program. What strategies work best for a given locality? What is the state's role?
- ❑ Discuss how the community can control or reduce mosquito populations effectively and with the least cost and environmental disruption.
- ❑ Coordinate local mosquito control programs with state and federal public health agencies to receive training for the operation of surveillance systems.
- ❑ Get local agencies involved in gathering data about disease and mosquito population patterns. Monitoring networks require maintenance and resources.

OPTIONS FOR MOSQUITO CONTROL ACTIVITIES AND PROGRAMS

Once the community has decided that there is a need for some sort of organized response to a mosquito or mosquito-borne disease problem, it is necessary to decide on the type of response and the magnitude of the effort. These decisions will be impacted by a variety of considerations, such as the severity of the problem, the financial resources of the community, public perceptions and attitudes, and the availability of technical expertise. This section deals with the technical aspects of organized mosquito control.

A primary focus of the MCC effort is to define the range of options for local mosquito programs from the simplest, but still effective, program, to the ideal program where resources are not the primary limiting factor. This document assumes that the programs described focus on both disease vector control and nuisance control. It also assumes that the area to be protected has been defined through some process (buffers around the community, city/county boundary, etc.). The following options describe three program levels:

- Level I (Minimal)—no resources to support mosquito control activities

- Level II (Intermediate)—little to moderate resources to support a program
- Level III (Comprehensive)—moderate to adequate resources to fund a complete mosquito control program

Level I – Minimal Program (No Resources to Support a Program)

Even when there is no staff or budget within the local community, there are things that can be done to reduce the threat of mosquito-transmitted disease and, to some extent, the irritation of pest mosquitoes. Here are some low-cost or no-cost options that will be helpful in many situations.

Public education. Remember that some aspects of mosquito control are personal responsibilities. Each citizen should be made aware of ways in which they can prevent mosquito breeding on and near their property; how they can reduce the risk of being bitten by observing personal protection measures; and how they can help to inform local health agencies by reporting bird deaths or other unusual events. However, knowledge does not always lead to action. Public recognition or other rewards may increase action by the community.

- Many public information brochures and other materials are available from the CDC and from state and local health departments. These can be reproduced at minimal cost and distributed with monthly utility bills or other community mailings.
- The public schools can be an excellent means of educating the public. The American Mosquito Control Association, the CDC, and other groups have teaching materials for the K-12 grades, and these may be available free or for a small charge.
- Citizen action groups can be an extremely effective resource to spread information about mosquito control, homeowner participation, and similar issues. Be sure to refer citizens to sites with reliable information.
- Educate and inform the local media. They are an important resource for delivering mosquito control messages to the public.

ELEMENTS OF A MINIMAL PROGRAM

- Institute a public information program emphasizing personal responsibility, ways in which people can prevent mosquito breeding, and how they can reduce the risk of being bitten by observing personal protection measures.
- Encourage reporting of unusual events, such as dead birds or sick domestic animals, to local health agencies.
- Institute community cleanup programs to eliminate larval habitats from back yards, commercial sites and abandoned premises.
- Citizen participation (reporting suspected mosquito larval habitats, reporting dead birds or other unusual events) is essential for efficient data gathering.
- Educate and inform the local media.

Source reduction. Community cleanup programs can be an effective way to eliminate larval habitats from back yards, commercial sites, and abandoned premises. Service groups (e.g., Rotary, Lions, Kiwanis, Sertoma), churches, scouts, and similar programs can be enlisted in the effort to increase community awareness and to support cleanup programs.

Level II – Intermediate Program (Little to Moderate Resources to Support a Program)

Communities with little to moderate resources available will have some capacity to conduct mosquito control activities, but cannot mount a comprehensive program. In this situation, the first question often is, “Should we use a contractor or should we develop an in-house program?” The answer depends on what other resources are available. In particular, the knowledge and training of individuals in the local health department (or mosquito control program if one is being developed) are factors. Other issues that will impact the decision include the size of the community being served, proximity to other

communities (with or without existing mosquito control programs), ecology of the region, and support by the community.

- In the absence of existing local expertise, it may be advisable to use a reliable contractor or, if feasible, form a collaborative or other arrangement with an adjoining county, parish, or municipality with an existing mosquito control program. Responsibility for program oversight and monitoring must be assigned to the appropriate agency. That agency should have the knowledge base and physical resources to carry out the program effectively.
- Regardless of which approach is selected, there should be a clearly defined statement of services or deliverables, and a clear performance evaluation document. What activities will be performed? What resources (equipment, staff, insecticides, etc.) will be provided? How often will inspections be conducted? How will efficacy

be measured? What happens in the event of non-performance?

The second common question deals with where to allocate the scarce resources. The answer will again depend somewhat on local conditions, but there are some generalizations that can be made. The end objective is to have a fully integrated mosquito management program that relies on a thorough understanding of the ecology of the mosquitoes of the area, the extent of the disease threat or nuisance problem, and the history of the community.

- The program should include all of the public education and source reduction activities identified in Level I above. Some funding could be directed at improving programs in the public

schools or, if needed, additional source reduction activities (e.g., draining or filling extensive larval breeding sites).

- The next step will be to focus on larval mosquito control, begun early in the season. This requires some knowledge of the local mosquito species and their ecology. Where are the larval habitats? When do they appear in the spring or summer? Thus, some mapping and record keeping will be needed. If insecticides are used, records must be kept of when, where, and how much of each material was used on any given day. In some localities, pre- and post-treatment larval counts are required to show whether the treatment was effective.

ELEMENTS OF AN INTERMEDIATE PROGRAM

- Continue measures established in the minimal-level program described above. Augment public education and source reduction efforts.
- Decide on the program format (e.g., in-house, contract, multi-jurisdictional collaborative).
- Decide who will be responsible (e.g., which agency has the resources and expertise to conduct the program?).
- Define the scope of the program—including such things as area to be covered and services to be performed—in relation to the available resources. Emphasize public education and source reduction, augmented by larval control. Consider adult mosquito control if sufficient resources are available.
- Ensure that all staff are appropriately trained and certified or licensed.
- Institute basic mosquito population monitoring to define the problem.
- Use passive disease monitoring (e.g., dead bird reporting) as an indicator of possible disease activity. Submit birds and/or mosquitoes for virus testing if such services are available.

- One or two mosquito traps should be purchased and placed in operation (the CDC portable light trap or any of several similar traps have been shown to be effective). These traps can be placed at crucial sites within the community, perhaps where past experience has indicated particularly severe pest problems or increased disease activity. This will aid in assessing the effectiveness of the program. For example, trap counts before and after a particular control activity can be compared.
- If additional funds are available, it may be worthwhile to purchase or contract for equipment for adult mosquito control (ULV sprayers, etc.). Since mosquitoes can fly substantial distances (from less than 1 mile to more than 15 miles, depending on the species and conditions), it may be difficult to protect communities with large outlying areas that can generate millions of mosquitoes. However, these methods can increase protection of the community from mosquitoes if an adequate area can be covered and the insecticides are applied appropriately (usually at dusk or after sunset, depending on the species being controlled).

Level III – Comprehensive Program (Moderate to Full Resources for a Program)

Communities with moderate to full resources will be able to develop and implement more comprehensive mosquito control programs. The recommendations in this section are drawn largely from the American Mosquito Control Association's Bulletin #4, *Organization for Mosquito Control* (1990). Please refer to that document or to the many excellent training manuals developed by state mosquito control associations for additional guidance in organizing a full-scale program.

A general principle of integrated control programs is that a specific control measure is only instituted when an action threshold, or “trigger,” is met. An example of thresholds and suggested responses for West Nile virus activity is shown in Appendix A, Decision Matrix. These are broadly defined thresholds, and individual states or communities may wish to institute more precise thresholds that reflect local experience and concerns.

One of the first things to recognize, once funding becomes available, is that mosquito control is a year-round activity. The information in this section gives a general picture of the activities that will be needed for the minimal program over the course of a year.

PRE- OR OFF-SEASON ACTIVITIES

General Issues

Many activities of the mosquito control program will normally be carried out in the “off season” when mosquitoes are not a problem—usually during the winter. These activities include staff training and certification; equipment purchase, repair and calibration; budgeting and other financial activities; and analysis of the previous year's data. In some areas, source reduction activities (see below) can also be done at this time.

Much of the information collected during mosquito control activities consists of maps, tables, and charts. Most of the information also is linked to a physical location. For this reason, it is useful to have a mapping program available to the mosquito control program. This can be done by coordinating with another city or county department that already has a geographical information systems (GIS) section or activity. Alternatively, there are inexpensive software programs that can be used if the expertise is available within the control program. The CDC offers a free software package, EpiInfo, which also contains a simple GIS program (EpiMap). This provides an inexpensive entry into the world of in-house data management and mapping. EpiInfo can also be used to design data collection forms, data entry screens, and elementary graphing capabilities.

Surveillance

Surveillance, as applied to vector-borne disease, is the organized monitoring of levels of virus activity, vector populations, infections in vertebrate hosts, human cases, weather, and other factors to detect or predict changes in the transmission dynamics of arboviruses. Since all of this information is rarely collected by a single agency, it is extremely important that the various data-collecting agencies actively communicate and exchange information.

- Review all published data, past health department records, and other data to determine the types of mosquito-borne diseases, numbers of cases by year and date of onset (or diagnosis), economic and other costs, if known. Review complaint calls for nuisance mosquitoes by year and date, and determine the peak periods of nuisance problems.
- Collect and review historical meteorological data for the area: temperature, rainfall, humidity, and wind direction. Plot this information against mosquito abundance (or nuisance calls) to see if there are any predictors of high mosquito abundance, disease transmission, etc.
- Map the locations of high-risk populations (e.g., elderly citizens), using local census or other community data. This will allow the program to prioritize resources if an epidemic should occur.

- Collect and review topographic maps, aerial photography, and other similar resources to help in locating probable larval habitats, concentrations of bird or other hosts of mosquito-transmitted viruses.
- Use the data collected above to decide where to place light traps or other sampling stations, and where to concentrate efforts to monitor larvae.
- Based on the foregoing information, select the areas at greatest risk within the service area (city, district, county, etc.) and plan to concentrate the available resources in those areas.

Species Delimitation

In some respects, a mosquito control program can be compared to a military campaign: it is crucial to know the enemy. The more that is known about the important species in the area, the more likely they can be effectively and economically controlled.

- Habitat mapping. The off-season is a good time to map the locations of larval habitats within the mosquito control district. It may also be useful to map major sources of mosquitoes that may be located outside the boundaries of the control district, if these are known or suspected sources of problems during the mosquito season.
- Seasonal characteristics. If not already done, take this opportunity to construct graphs of seasonal abundance of mosquitoes, by species. This should be done for larval surveys as well as adult surveys. Over several years, it will be possible to construct an average count for each species, by week. When the current counts for a particular species rise above the long-term average, this may indicate an emerging problem.

Control Activities

This is the most visible part of the program, but its success is strongly dependent on attention to the points covered above.

- Source reduction. Several types of source reduction can be carried out during the off-season: clearing of stream channels, community cleanup (e.g., door-to-door inspections, tire amnesty programs), and similar activities.
- Larval control. Most control is done later in the season, but some areas can be treated before they become flooded by spring rains or runoff.
- Adult control. No adult control is done at this time.
- Public education. Public education, especially activities focused on K-12 school programs, can be carried out at any time of the year. Arrange for presentations at meetings of civic groups, nature groups, service clubs, and other groups that have an impact on the local community. To reach the agricultural community, coordinate activities with local county extension agents where those services are available.

EARLY-SEASON ACTIVITIES

Surveillance

In early-season activities, as above, surveillance gathers the intelligence data needed to combat the mosquitoes and prevent disease transmission.

- Larvae. With the arrival of spring warming and rain or flooding, *Aedes* and *Ochlerotatus* eggs will hatch, and diapausing *Culex* females will emerge, take a blood meal, and begin laying eggs. This is the time to begin monitoring larval populations. Triggers for control action should be determined: how many larvae per dip represent a health threat or a nuisance problem?

- Adults. Similarly, light traps, gravid traps, or other methods should be used regularly to monitor adult mosquito abundance. Triggers for control action should be determined: how many females per trap night of a particular species pose a health threat or a nuisance problem?
- Disease surveillance. Vertebrate hosts (e.g., dead birds as indicator for West Nile virus) should be monitored for evidence of virus activity. This may be simply recording and mapping the locations of dead birds reported by the public. Depending on other resources, a state laboratory or other facility may be available to perform virus testing on dead birds. Test kits are available for testing dead birds and mosquito pools without elaborate laboratory facilities. Mosquito infection rates can be an important indicator of a disease threat. The state health laboratory or other facility may be able to provide this service. Infection in domestic animals (horses, etc.) and humans is an indicator of impending trouble and an indication that immediate action is required. [See Appendix A: Decision Matrix]

Species Delimitation

- Habitat mapping should be continued during the course of the mosquito season. New locations should be plotted on the map or entered into the GIS database. New locations should be added to the inspection and treatment routes of the field staff.
- Seasonal abundance characteristics may give evidence of approaching problems. Are the numbers of *Culex pipiens* far above normal? What about *Culex tarsalis* (western states)? Is *Aedes vexans* more abundant than normal?

Control Activities

- Source reduction. Activities can continue during this period. Efforts should concentrate increasingly on the elimination of potential disease vector species larval habitats.
- Larval control. Biocontrol agents, such as mosquito eating fish (*Gambusia* spp. and others), copepods, or other agents, can help to balance out a good control program. “Biological pesticides” such as *Bacillus thuringiensis* var. *israelensis* (B.t.i.) and *Bacillus sphaericus* are effective mosquito control agents.
- Chemical control of larvae includes a variety of materials. Larvicidal oils and monomolecular films cover the water surface and prevent the larvae from breathing. Growth regulators, such as methoprene, affect the development of the mosquito larvae, preventing the adult from emerging from the pupa. Several other materials are available in some areas or for particular applications.
- Adult control. Selective use of adulticides may be advisable if there is evidence of virus activity early in the season, or if nuisance species are at high levels.
- Public education. Newspaper, radio, and television announcements can be prepared to increase public awareness of the threat of mosquito-transmitted disease. Coordination with local media can increase the community’s awareness of the types of work done by the mosquito control program.

MID- AND LATE-SEASON ACTIVITIES

Activities for the remainder of the mosquito control season will be much the same as for the early season, with the exception that more and more effort will be dedicated to larviciding and, when needed, adulticiding. Disease surveillance data will guide the level of mosquito control, especially control of adult mosquitoes. Public education and close contact with media resources will be a continuing need.

As mosquito populations decline with the onset of cold weather, the program will return to the pre-season/off-season routine, in preparation for the next year.

ELEMENTS OF A COMPREHENSIVE PROGRAM

- Continue measures established in the intermediate-level program described above. Augment public education and source reduction efforts.
- In collaboration with other relevant agencies and stakeholders, define the full scope of the expanded program.
- Establish an advisory board or similar structure to provide feedback and communication between the program and relevant stakeholders.
- Hire and train appropriate professional staff needed to fulfill the requirements of the expanded program.
- Procure the necessary equipment, chemicals and other materials needed to carry out the expanded program.
- Build on the existing monitoring program, establishing a long-term database for comparison to current-year data.
- Prepare an emergency response plan for dealing with vector-borne disease outbreaks.
- Increase disease surveillance activities by instituting sentinel flocks, mosquito testing or other techniques as appropriate.
- Build risk maps to assign priorities to areas within the district using census data, mosquito abundance data, disease incidence and other relevant data.
- Maintain good communication among the Centers for Disease Control and Prevention, state public health and local public health agencies.
- Evaluate the governmental disease surveillance network.
- Evaluate and improve the disease reporting system among physicians, hospitals, laboratories and public health agencies.
- Develop and maintain a responsive animal and vector disease reporting system among veterinarians, wildlife agencies, the public, mosquito control contractors, laboratories and state and local public health agencies.
- Keep the public and public officials informed regarding disease incidence projections, cases identified and response planning.

INFORM THE PUBLIC

Mosquito control programs need the support of an informed public. Many of the successful strategies for control involve individuals, their families and their neighborhoods. The public also has concerns about the problems related to the mosquito populations and about insecticides and spraying.

Informing the public shows a respect for the community and will lead to a stronger, better supported program that is tailored to the community and its values. Development of a communications plan that includes public education about preventing the breeding of mosquitoes, personal protection guidance, and the activities and success of the agencies involved is critical to the success of the program.

DEFINE THE GOALS FOR PUBLIC INFORMATION

The public information challenges of mosquito control are many. Mosquito control includes two areas of responsibility: individual and public. Areas of individual responsibility relate to personal actions residents can take to reduce personal risk from mosquitoes, such as eliminating breeding pools on their property and using insect repellants. Public responsibility relates to the development and maintenance of community-wide mosquito control activities and programs. Public information strategies will vary based on which area of responsibility is being impacted and the goal to be achieved. The information needs vary depending on whether the goal is to:

- Educate policy makers and gain their support for policy issues;
- Inform the public about mosquito control generally;
- Provide instructions to the public to prevent exposure and lower risk;
- Influence the public regarding a permanent control strategy;
- Deal with a public health crisis, such as West Nile virus;
- Inform the public of pesticide risks and benefits;
- Inform the public about the use and timing of pesticides in their community; or
- Gain support for financial resources for mosquito control.

A respected spokesperson should be identified. This may be the local health official or another public official with credibility and profile in the community. The spokesperson(s) could come from academia, the medical community, the local hospital, or public health. The lead agency at the local level will want to designate a public information officer or team to develop materials, inform the press, respond to questions, and network with information officers in related organizations, such as emergency medical services, hospitals, county or city manager's offices, the state, etc.

Strategies to inform the public can include press education prior to the mosquito season; educational meetings with policy-makers such as city councils and county commissioners; preparation of materials for the public; web-site development; plans for a hotline and recorded messages; and regular information to the public about mosquito surveillance and disease incidence.

CREATE EFFECTIVE MESSAGES

A proactive approach will involve developing a simple message, easily understood that resonates and is memorable. Many states have already initiated public health campaigns such as the 2003 "Fight the Bite" campaign. When developing campaigns, it is important to have a unified message across the state. Other public health campaigns may serve as models for community awareness. A successful campaign:

- Utilizes web sites, public service announcements and information hotlines as tools for community education and involvement;
- Develops multiple strategies to reach people at home, work, school, in shopping areas and in places of worship;
- Provides succinct messages to the public throughout the year and emphasizes prevention as the best protection against illness; and
- Assures that programs are sustainable even in the absence of mosquito-borne illness in the community.

INFORM THE PUBLIC – PLANNING AND ACTION CHECKLIST

- Develop an information exchange process that will keep the public in tune with decisions and anticipated actions.
- Determine who should be included in the public information network to plan for the information campaign or campaigns. What sister agencies or neighboring jurisdictions need to be involved?
- Decide if there will be proactive press education prior to the mosquito season.
- Determine who will develop and update web sites. What links will be established?
- Decide what specific information can be given to the public about the use and timing of pesticide applications.
- Identify language barriers that need to be considered when developing campaigns .
- Anticipate objections to the program by a minority opinion that may be vocal enough to disrupt the project or lead to minority reports.
- Establish a follow up mechanism such as a survey to determine the success of education and outreach.
- Develop a pre-season campaign to educate the public.
- Designate a spokesperson to handle medical questions and work with the coroner's office and the hospitals if death and/or illness occur.
- Prepare fact sheets for physicians and the public.
- Educate key decision-makers.
- Maintain statewide data and coordinate information campaigns with a single, unified message to the public on prevention of mosquito-borne illness.

**If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org.
You can submit comments electronically, by fax or by mail.**

RESOURCES FOR MORE INFORMATION

There are many resources to help in establishing a mosquito control program. The following list provides a basic sampling of these resources from government agencies, professional associations, and universities.

BOOKS

Beaty, B. J. and W. C. Marquardt (Eds.). 1996. *Biology of Disease Vectors*. Niwot, CO, Univ. Press of Colorado [Second edition is in press, expected 2004].

Monath, T. P. (Ed.). 1988. *The Arboviruses: Epidemiology and Ecology* (5 vols.). Boca Raton, FL, CRC Press.

Service, M. W. 1993 *Mosquito Ecology. Field Sampling Methods*. 2d Ed. London, Elsevier Applied Science.

Smolinski, M. S., M. A. Hamburg, and J. Lederberg (Eds.). 2003. *Microbial Threats to Health: Emergence, Detection, and Response*. Washington, DC, National Academy Press. 2003.

JOURNALS

Bulletin of the Society for Vector Ecology (S.O.V.E., 1966 Compton Ave., Corona, CA 92881) - www.rove.org

Emerging Infectious Diseases (Centers for Disease Control and Prevention, 1600 Clifton Rd., Atlanta GA 30333) - www.cdc.gov/ncidod/EID/index.htm

Journal of the American Mosquito Control Association. (American Mosquito Control Association, P. O. Box 234, Eatontown, NJ 07727-0234) - www.mosquito.org

Wing Beats (Florida Mosquito Control Association & AMCA, P.O. Box 60005, Fort Myers, FL33906) - www.floridamosquito.org

BULLETINS AND MANUALS

AMCA. 1990. *Organization for Mosquito Control*. Bulletin #4. Eatontown, NJ, American Mosquito Control Association.

CDC. 2001. [*Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance*](#).

[*Prevention, and Control*](#). Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO
www.cdc.gov/ncidod/dvbid/westnile/resources/wnguidelines2001.pdf.

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Moore, C. G., R.G. McLean, et al. 1993. [*Guidelines for Arbovirus Surveillance in the United States*](#). Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO.

AGENCIES AND ORGANIZATIONS

Americana Mosquito Control Association - P. O. Box 234, Eatontown, NJ 07727-0234) - www.mosquito.org

Association of State and Territorial Health Officials (ASTHO) www.astho.org

Centers for Disease Control and Prevention - 1600 Clifton Rd., Atlanta GA 30333 - www.cdc.gov

National Association of County and City Health Officials (NACCHO) www.naccho.org

Society for Vector Ecology (S.O.V.E., 1966 Compton Ave., Corona, CA 92881) - www.rove.org

State health departments - See www.StatePublicHealth.org

State Public Health Vector Control Conference (SPHVCC) - c/o Nolan H. Newton, North Carolina Department of Environment and Natural Resources, 1631 Mail Service Center, Raleigh, NC 27699-1631

U.S. Department of Agriculture (USDA) -
www.aphis.usda.gov/lpa/issues/WestNileVirus/WestNileVirus.html

U.S. Environmental Protection Agency (EPA)
www.epa.gov/pesticides/factsheets/mosquitocontrol.htm

National Pesticide Information Center, Oregon State University, Corvallis, OR. www.npic.orst.edu/

University extension and research medical/veterinary entomology programs

MISCELLANEOUS

CDC Evaluation Working Group - Examples of evaluation tools and resources that may be helpful during the formation and implementation of a mosquito control program can be found at www.cdc.gov/eval/resources.htm.

The Mosquito Abatement for Safety and Health Act (MASH Act) – A copy of the Act and its status can be found at <http://thomas.loc.gov/cgi-bin/bdquery/z?d108:SN01015:|TOM:/bss/d108query.html>. A summary of the Act can be found at www.ncsl.org/statefed/health/HR4793summary.pdf.

MosquitoZone – Information about community action can be found at www.mosquitozone.com/home. This site requires visitors to register before viewing all information.

Public Health Foundation – For insight to non-technical skills that may be required of the workforce, visit www.train.org. Click on the Core Competencies prompt and then scroll through the background documents found on the left side of the page. It is important to read the introduction in order to properly apply the skills described later in the document.

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APPENDIX A

Suggested Guidelines for Phased Response to West Nile Virus Surveillance Data*

Risk category	Probability of human outbreak	Definition	Recommended response
0	None	Off-season: adult vectors inactive; climate unsuitable.	Develop West Nile Virus response plan. Secure surveillance and control resources necessary to enable emergency response. Initiate community outreach and public education programs. Conduct audience research to develop/ target education & community involvement. Contact community partners.
1	Remote	Spring, summer, or fall: areas anticipating West Nile Virus (WNV) epizootic based on previous WNV activity in the region; no current surveillance findings indicating WNV epizootic activity in the area.	Response as in category 0, plus: conduct entomologic survey (inventory and map mosquito populations, monitor larval and adult mosquito density); initiate source reduction; use larvicides at specific sources identified by entomologic survey and targeted at likely amplifying and bridge vector species; maintain avian mortality, vector and virus surveillance; expand community outreach and public education programs focused on risk potential and personal protection, and emphasize residential source reduction; maintain surveillance (avian mortality, mosquito density/IR, human encephalitis/meningitis and equine illness).
2	Low	Summer, or fall: areas with limited or sporadic WNV epizootic activity in birds and/or mosquitoes. No positives prior to August.	Response as in category 1, plus: increase larval control, source reduction, and public education emphasizing personal protection measures, particularly among the elderly. Enhance human surveillance and activities to further quantify epizootic activity (e.g., mosquito trapping and testing). Implement adulticide applications if vector populations exceed locally established threshold levels, emphasizing areas where surveillance indicates potential for human risk to increase.
3	Moderate	Spring, summer, or fall: areas with initial confirmation of epizootic WNV in birds before August; a horse and/or a human case; or sustained WNV activity in birds and/or mosquitoes.	Response as in category 2, plus: intensify adult mosquito control in areas where surveillance indicates human risk; initiate adult mosquito control if not already in progress; initiate visible activities in community to increase attention to WNV transmission risk (speaker, social marketing efforts, community mobilization for source reduction, etc.); work with collaborators to reduce risks to elderly (e.g., screen repair).
4	High	Spring, summer, or fall: quantitative measures indicating WNV epizootic activity at a level suggesting high risk of human infection (e.g., high dead bird densities). In early summer, sustained high mosquito infection rates, multiple positive mosquito species, horse or mammal cases indicating escalating epizootic transmission, or a human case and high levels of epizootic activity. Areas with early season positive surveillance indicators where WN epidemic activity has occurred in the past.	Response as in category 3, plus: expand public information program to include TV, radio, and newspapers (use of repellents, personal protection, continued source reduction, risk communication about adult mosquito control); increase visibility of public messages, engage key local partners (e.g., government officials, religious leaders) to speak about WNV; intensify and expand active surveillance for human cases; intensify adult mosquito control program, repeating applications in areas of high risk or human cases.
5	Outbreak in progress	Multiple confirmed cases in humans; conditions favoring continued transmission to humans (e.g., persistent high infection rate in mosquitoes, continued avian mortality due to WNV).	Response as in category 4, plus: intensify emergency adult mosquito control program repeating applications as necessary to achieve adequate control. Enhance risk communication about adult mosquito control. Monitor efficacy of spraying on target mosquito populations. If outbreak is widespread and covers multiple jurisdictions, consider a coordinated widespread aerial adulticide application; emphasize urgency of personal protection through community leaders and media; and emphasize use of repellent at visible public events.

Local and regional characteristics may alter the risk level at which specific actions must be taken. [CDC. 2001. Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance, Prevention, and Control. Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO. Available at www.cdc.gov/ncidod/dvbid/westnile/resources/wnvguidelines2001.pdf.]

APPENDIX B

Suggested Components for Bids or Contracts for a Mosquito Control Program

Governmental agencies may need to purchase mosquito control services from private vendors. The following reflects components that may be included in bid and/or contract specifications for a quality program and effective results. Any agency contracting for services should contact their agency attorney for guidance.

Description of Services

- Surveillance, mapping and monitoring of potential mosquito sites
- Monitoring and suppression of larval and adult populations
- Requirement to use Integrated Pest Management control methods and materials sanctioned for use by the United States Environmental Protection Agency, the Centers for Disease Control and Prevention, the U.S. Department of Agriculture, and the American Mosquito Control Association.
- Public outreach program including:
 - 24 hour phone line
 - 24 hour response/resolution timeline
 - printed materials and media advertisements
 - information presentations
 - advanced public notices of scheduled sprayings
 - provisions to exclude properties from being sprayed at owner's request
- Reports detailing all larviciding, trapping and adulticiding activities
- Reports of public outreach and citizen interaction activities
- Year end reports summarizing the season's results and activities with recommendations for the following year's program.
- Copies of all maps, records, logs, complaints and correspondence upon request.
- Description of proposed staffing levels
- Description and number of major equipment items
- Description of the activities, methods and materials to be used including:
 - Pesticides with EPA Establishment Number and Registration Numbers
 - Requirement to use pesticides consistent with FIFRA (Federal Insecticide, Fungicide and Rodenticide Act)
 - Application rate
 - Acreage to be covered
 - Times of coverage
 - Details of reporting
 - Need for neighborhood notification
 - Hotline, if necessary. Or 24 hour local customer access telephone number for complaints and information.
 - Monitoring data
 - Time lines, including whether contract is multi-year, due dates, etc.
 - Methods used for surveillance
 - Control methods
 - Evaluation plan
 - Access to real time surveillance, mapping, and control data, including maps
 - Access to contractor personnel during regular hours and after-hours emergency access
 - Standards for resolution of complaints, e.g. 24 hour

Description of Contractor

- Name and address of company or corporation with notarized signature page
- Name of designated contact person with contact information
- Names and addresses of the principal employees or officers with description of their qualifications
- Proof of licenses and certificates required for services
- Proof of insurance, bonds or other surety
- Indemnifications of governmental agency
- Training and certification of employees
- List of references

Financial Arrangements

- Payment, terms of payment, cost of per acre (if applicable), larviciding per basin or drain, larval site inspection services, surveillance cost per trap per night
- Assurance that all goods are free of all liens, encumbrances and security interests
- Warranties of any equipment to run to contracting agency and its successors
- Contract subject to availability of funding

Responsibilities of Governmental Agency

- Terms of bid opening and date and time of submission
- Activities to be performed by governmental staff
- Payments will be paid for all goods and services 30 days after receipt of services
- Staff contact with phone numbers and address
- Provision for extension or expansion of services
- Circumstances justifying cancellation of agreement

Standard Contract Items

- Equal Employment Opportunity assurance
- Workers Compensation
- Comprehensive general liability insurance and automobile insurance